Lighting for seniors

Senior Vision

- Smaller pupils (reduced light entering the eye)
- Loss of ocular transparency (scattering)
- Yellowing of the ocular media
- Loss of accommodation

Photobiological Effects

- Neuroendrocrine consequences
- Vitamin D synthesis
- Sleep disorders
- Depression
- Reduced calcium absorption

Photobiological Effects

- Sleep/ wake cycle requires min 200 fc
- Requires 20 minutes per day out of doors..sleep disorders in 65% of nursing home residents

Measuring Light "Quality"

- Disability Glare
- Discomfort glare
- Veiling reflections
- High luminance ratios

Categories of visual disability

- Pre-retinal scatter
  - normal retinas
  - Increases in light levels may do more harm than good by increasing the amount of light scattered in the eye

Categories of visual disability

- Retinal dysfunction
  - Acuity and contrast sensitivity reduced
    - Benefit from higher light levels

Lighting for Pre-retinal Scatter

- Disability glare
- Cataracts
- Provide the highest possible object contrast while limiting the total amount of light entering the eye
- Simply adding fcs makes the problem worse

Lighting for Pre-retinal Scatter

- Control non-task light
  - Shield windows
  - Baffled luminaires
- Specular surfaces avoided

Lighting for Retinal Dysfunction

- See IESNA recommended fc levels..use upper levels with adequate glare control

Lighting Quality

- Freedom from glare (disability + discomfort)
- Freedom from veiling reflections
- Freedom from flicker
- Adaptation control

Discomfort Glare: Avoid

- Bright sources
- Sources that are large in area
- Sources close to line of sight

Discomfort Glare: metrics

- Visual Comfort Probabilities (VCP): select fixtures with high VCP's

Discomfort Glare: Veiling Reflections

- Sources spectrally reflect off a task into viewers eyes
  - Avoid spectrally reflective surfaces
- Review candlepower distribution curve

Flicker

- High frequency ballasts best avoid electromagnetic ballasts
- Addition of some incandescent
- Dementia and Alzheimer's consequences

Adaptation Control

- Create adaptation opportunities at points of egress from indoors to out
  - Daylight hours: lobbies higher fc
  - Darkness hours: lobbies dimmer

Lighting Fundamentals

Luminaire

- Complete lighting unit
  - One or more lamps
- Components to distribute light
  - Position lamps
  - Protect lamps
- Connect to power supply

Photometric Data

- Candlepower Distribution Curves
- Luminaire Efficiency
- Coefficient of Utilization (CU)
- Spacing Criteria (S C)

Candlepower

- Luminous intensity expressed in candelas.
- Plots of luminous intensity, called candlepower distribution curves, are used to indicate the intensity distribution characteristics of reflector-type lamps.

Candlepower

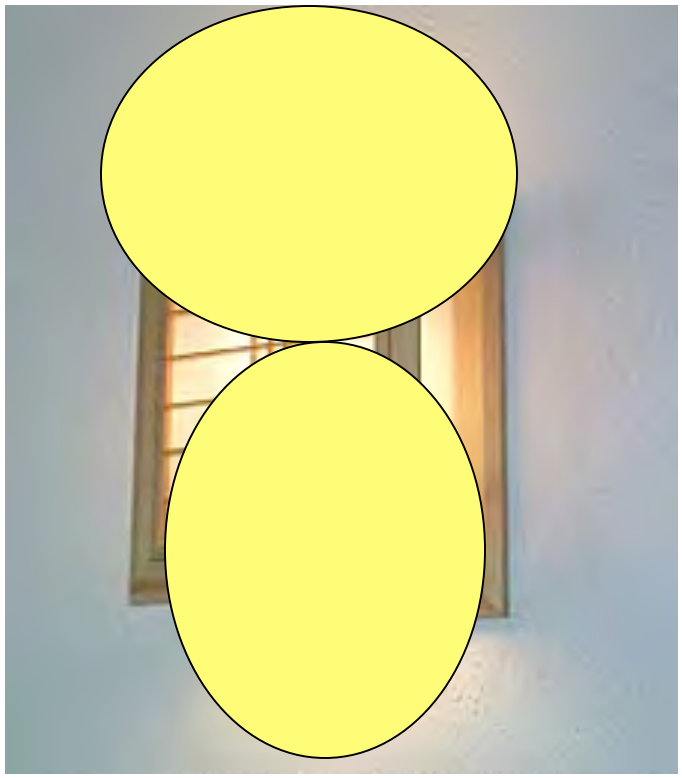
- A measure of intensity mathematically related to lumens.
- Describes the light intensity of a lamp in a certain direction.

Distributions

- Luminaires are classified by percentage of illumination directed upward and downward

Distributions

- Candle Power Distribution Curves used to diagram illumination



Candle Power Distribution Curve

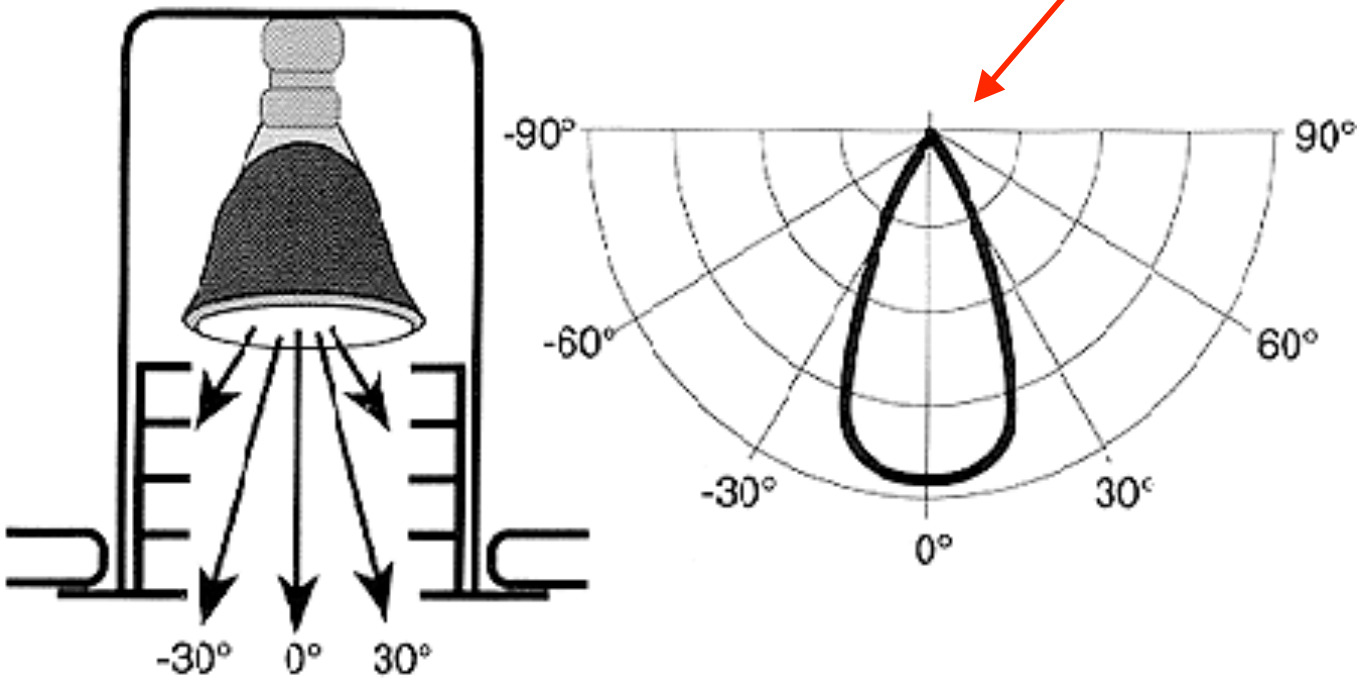
- cross sectional "map" of intensity (candelas)
  - It is a two dimensional representation and therefore shows data for one plane only.

Candle Power Distribution Curve

- If the distribution of the unit is symmetric, the curve in one plane is sufficient for all calculations.
- If asymmetric, such as with street lighting and fluorescent units, three or more planes are required.

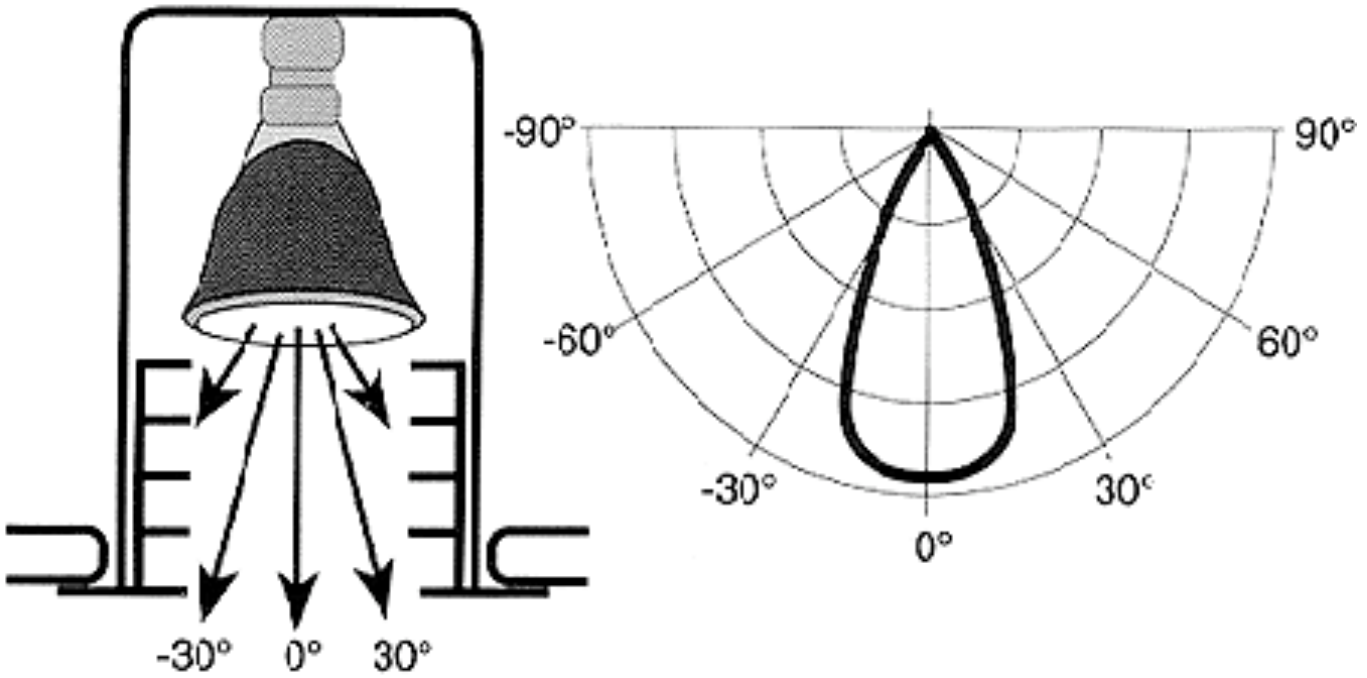
Candle Power Distribution

- Polar graphs
- the candlepower distribution of a luminaire is usually presented as a **polar graph**



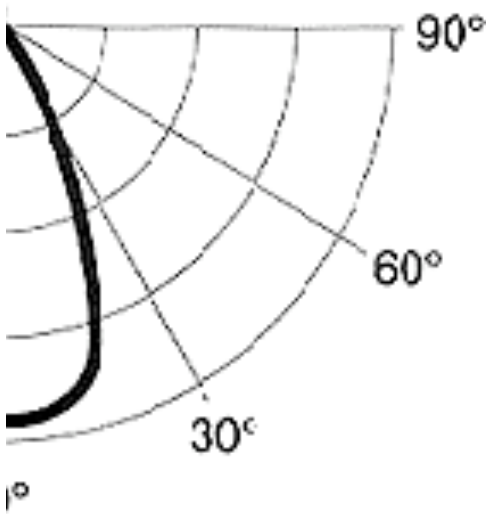
Candle Power Distribution

- The heavy dark line represents the luminous intensity at various positions beneath the luminaire opening.



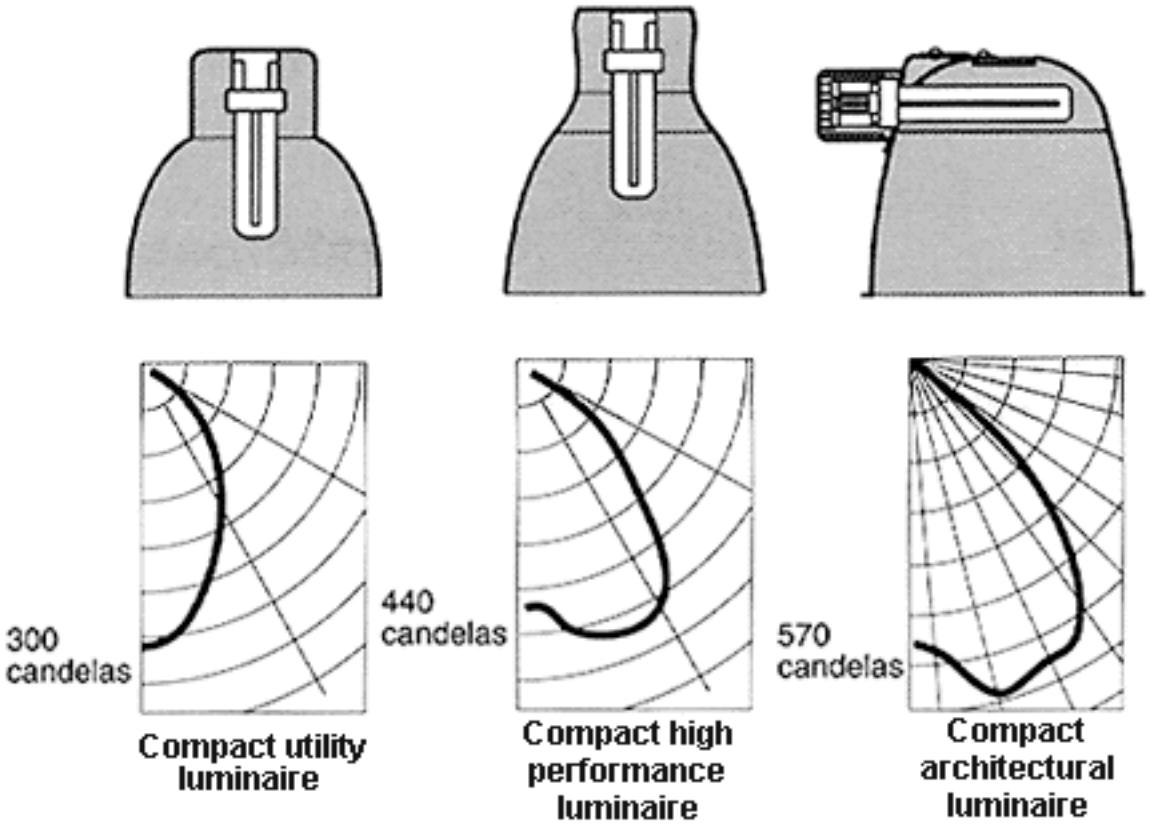
Candle Power Distribution

- If the curve is symmetrical, only 1/2 of the distribution is shown

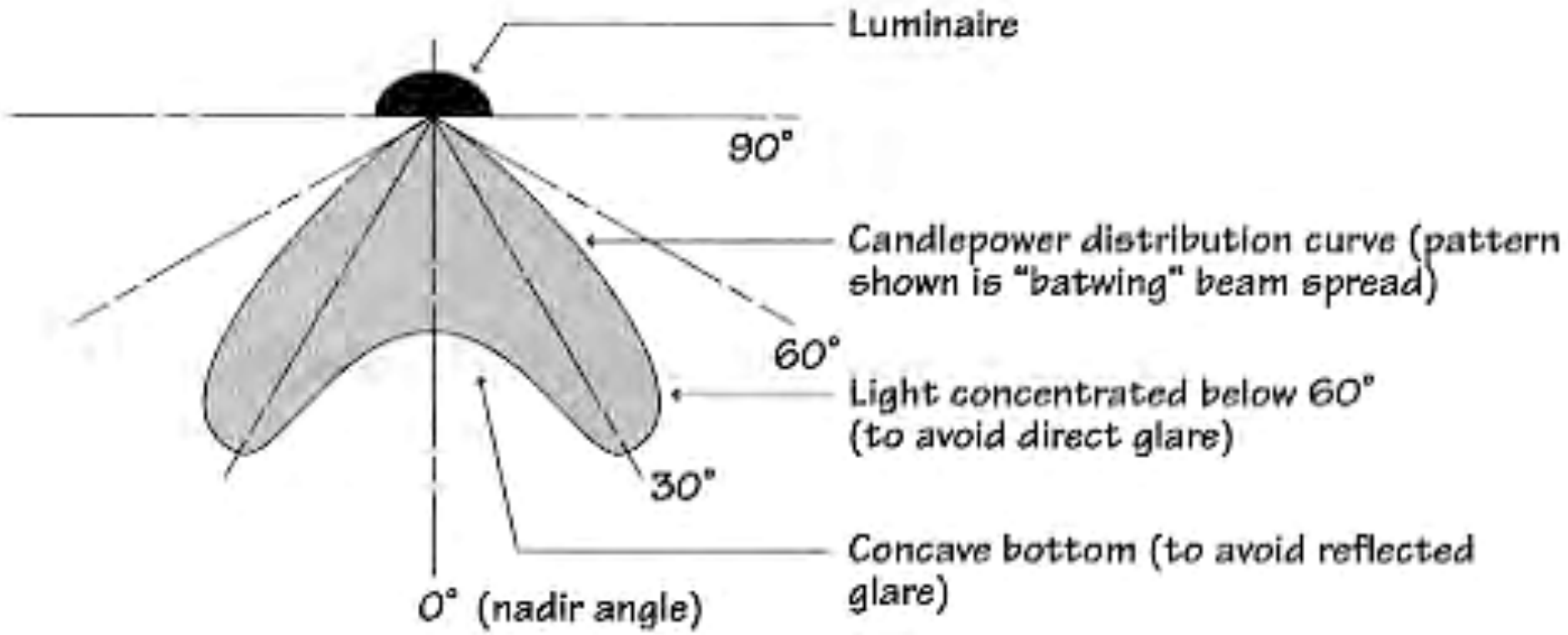


Candle Power Distribution

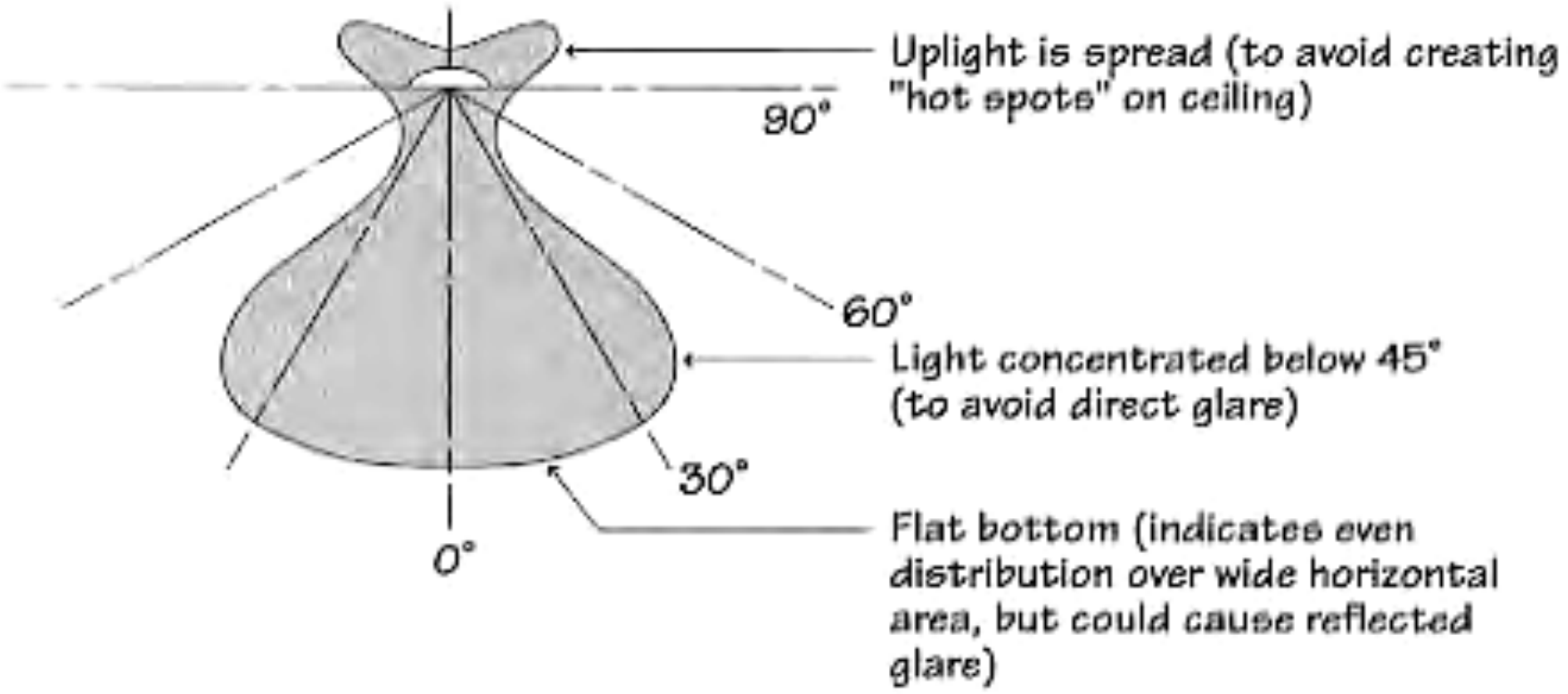
- Candlepower distributions are one of the basic ways of comparing lighting system performance.



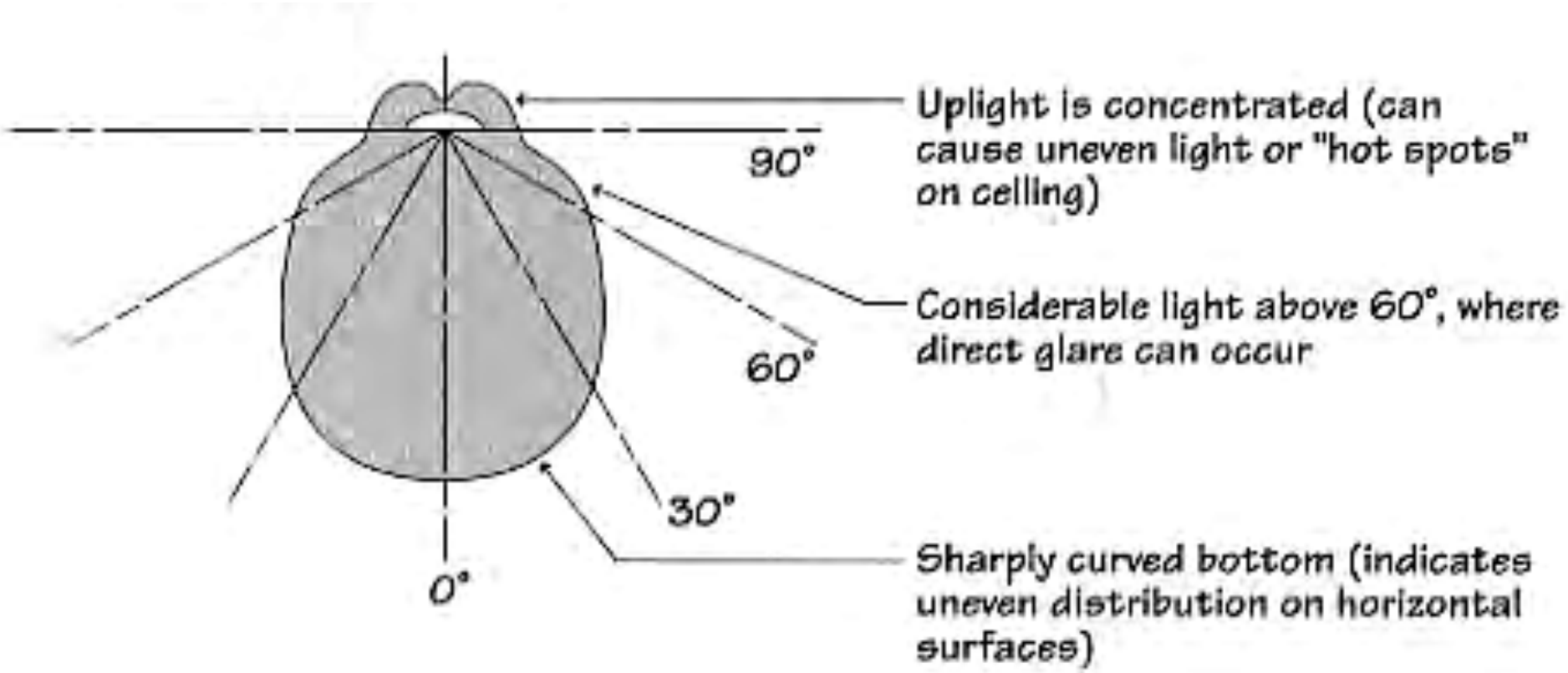
Candle Power Distribution: Recessed Luminaire



Candle Power Distribution: Suspended luminaire



Candle Power Distribution: Suspended luminaire



Quantity of Illumination: Light Output

- The most common measure of light output (or luminous flux) is the lumen.
  - Light sources are labeled with an output rating in lumens.

Lighting Metrics: Quantity of Light

- Luminous Flux (Light Output).
- This is the quantity of light that leaves the lamp, measured in lumens (lm).
- Lamps are rated in both initial and mean lumens.

Lumen

- Measurement of light output
- One lumen is equal to the amount of light emitted by one candle that falls on one square foot of surface located one foot away from one candle.

Quantity of Illumination: Light Output

- A T12 40-watt fluorescent lamp may have a rating of 3050 lumens.
- Most lamp ratings are based on initial lumens (i.e., when the lamp is new).

Light Levels

- Light intensity measured on a plane at a specific location is called *illuminance*.
- Illuminance is measured in *footcandles*

Footcandle

- The average illumination resulting when one lumen of light falls on one square foot of surface.
- Standard unit of measure for illumination on a surface.
  - The Average footcandle level on a square surface is equal to the lumens striking the surface, divided by the area of the surface.

Maintained Footcandles

- Light level after light loss factors are considered over a period of time.
- Light Loss Factor (LLF) include those affecting light output and also room surface reflectances, room size/proportions, dirt and dust buildup.

Maintained Footcandles

- While light output may describe either the output of a light source or fixture, maintained footcandles always takes into account the efficiency of the fixture in transmitting light to the workplane.

Lighting Metrics: Quantity of Light

- Mean lumens
- indicate the average light output over the lamp's rated life,
- which reflects the gradual deterioration of performance due to the rigors of continued operation

Quantity of Light

- "lumen output" is a term also used to describe a luminaire's light output, not just a lamp's.

Quantity of Light

- **Illuminance** (Light Level).
- Illuminance is the measurement of how bright a point source of light appears to the eye.
- Measured in foot-candles (or lux).

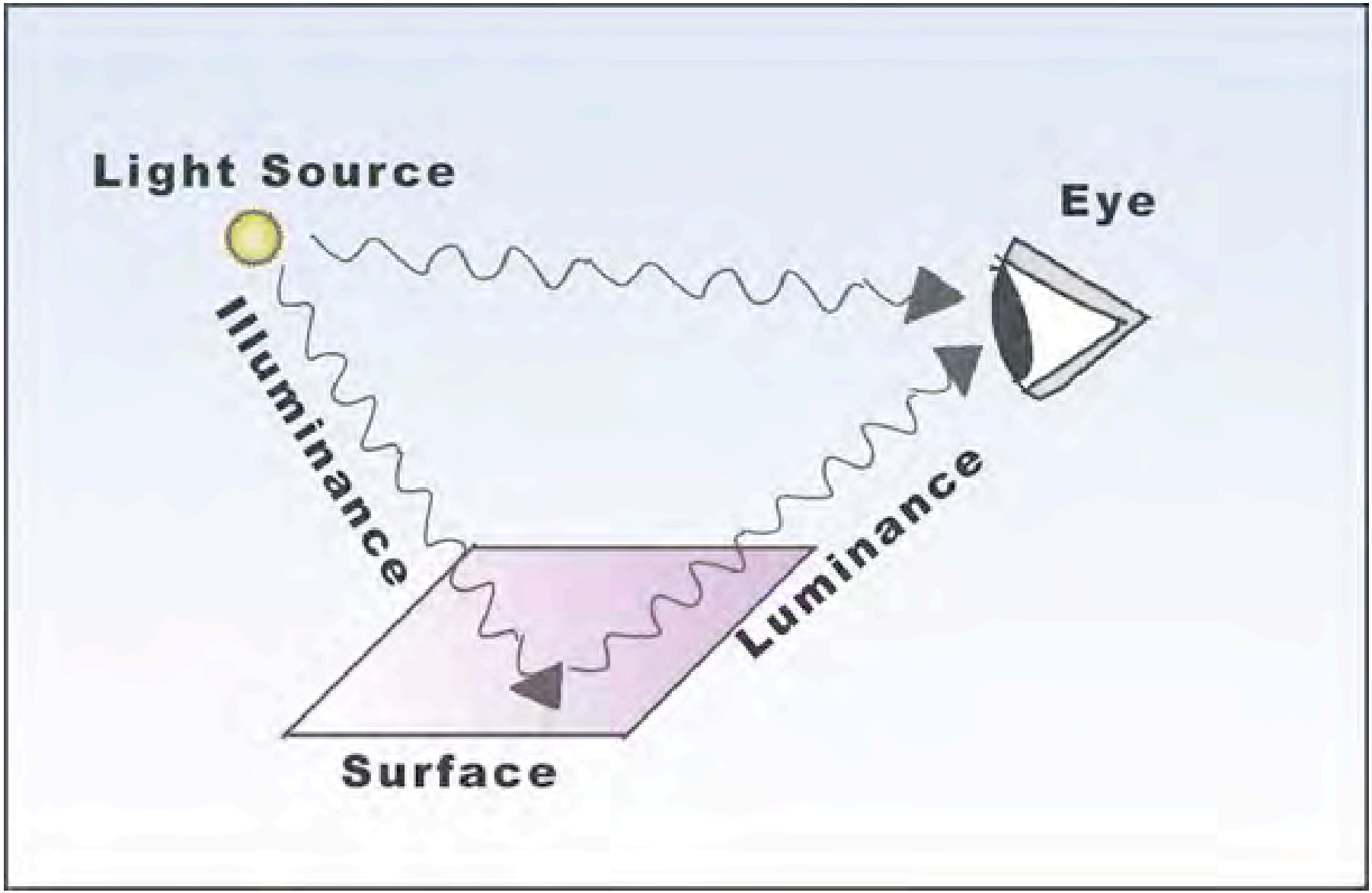
Illuminance

- **Initial footcandles** indicates a light level after new lamps are installed.

Brightness

- *Luminance*, sometimes called brightness.
- This measures light "leaving" a surface in a particular direction, and considers the illuminance on the surface and the reflectance of the surface.

Illuminance v. Luminance



Quantity of Light

The human eye is a sophisticated piece of machinery; it is able to adjust to a wide range of light levels, including about 10,000 footcandles on a sunny day to about 0.01 footcandles under full moonlight. However, optimum ranges of light levels have been established for various tasks so that those tasks are performed most efficiently

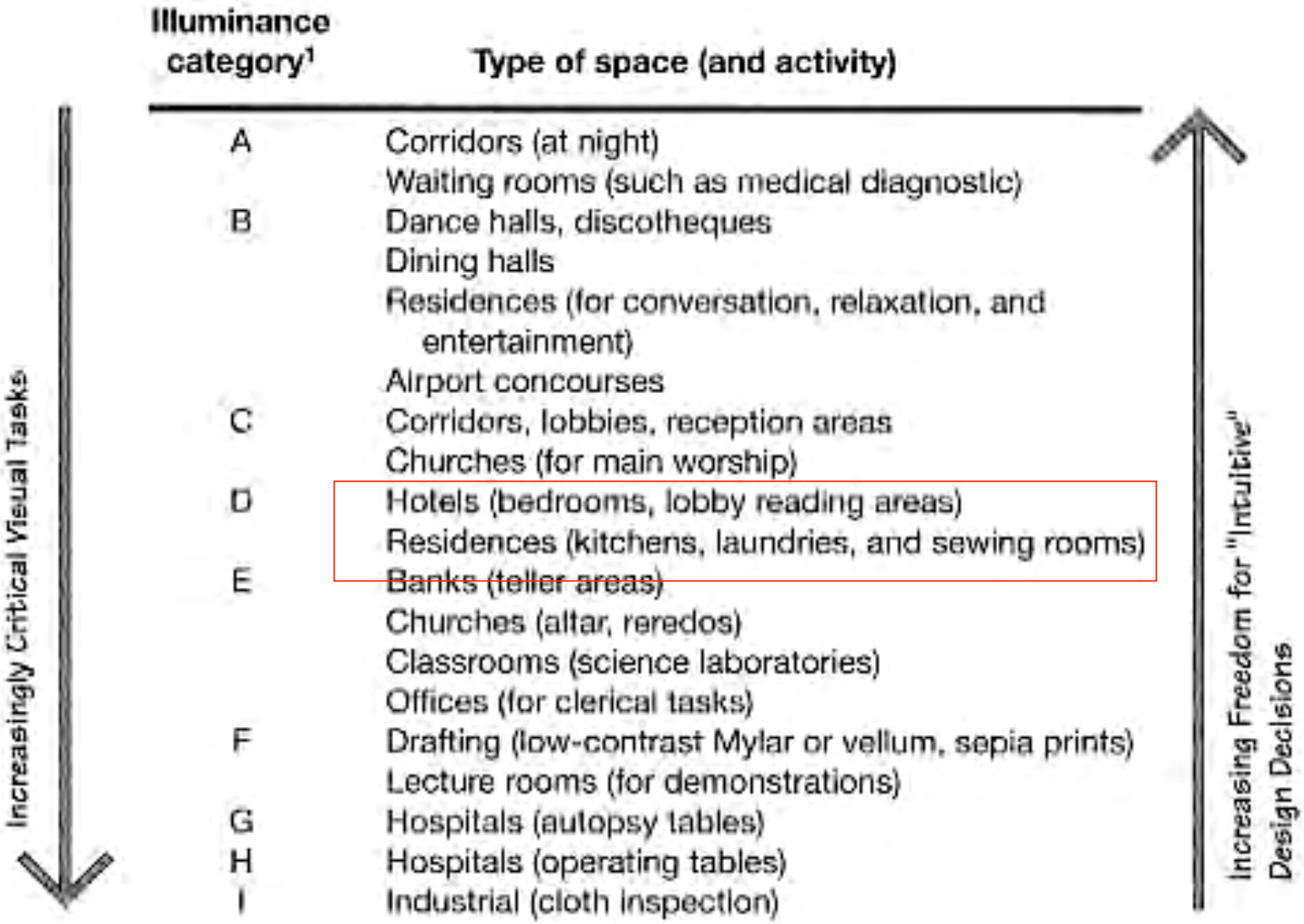
Target Light Levels

- Illuminating Engineering Society of North America
- Target light levels by considering the following:

– the task(s) being performed (contrast, size, etc.)

– the ages of the occupants

– the importance of speed and accuracy


Illuminance category[1]
Type of space (and activity)
A
Corridors (at night)
Waiting rooms (such as medical diagnostic)
B
Dance halls, discotheques
Dining halls
Residences (for conversation, relaxation, and entertainment)
Airport concourses
C
Corridors, lobbies, reception areas
Churches (for main worship)
D
Hotels (bedrooms, lobby reading areas)
Residences (kitchens, laundries, and sewing rooms)
E
Banks (teller areas)
Churches (altar, reredos)
Classrooms (science laboratories)
Offices (for clerical tasks)
F
Drafting (low-contrast Mylar or vellum, sepia prints)
Lecture rooms (for demonstrations)
G
Hospitals (autopsy tables)
H
Hospitals (operating tables)
I
Industrial (cloth inspection)
Increasingly Critical Visual Tasks
Increasing Freedom for "Intuitive" Design Decisions

IESNA Recommended Illuminance Values

Illuminance category	Ranges of illuminance maintained in service, lux (fc)	Type of activity
General illuminance throughout room:		
A	20–30–50 (2–3–5)	Public spaces with dark surroundings
B	50–75–100 (5–7.5–10)	Simple orientation for short temporary visits
C	100–150–200 (10–15–20)	Working spaces where visual tasks are only occasionally performed
Illuminance on task:		
D	200–300–500 (20–30–50)	Performance of visual tasks of high contrast or large size: reading printed material, typed originals, handwriting in ink, and good xerography; rough bench and machine work; ordinary inspection; rough assembly
E	500–750–1000 (50–75–100)	Performance of visual tasks of medium contrast or small size: reading medium pencil handwriting, poorly printed or reproduced material; medium bench and machine work; difficult inspection; medium assembly
F	1000–1500–2000 (100–150–200)	Performance of visual tasks of low contrast or very small size: reading handwriting in hard pencil on poor-quality paper and very poorly reproduced material; highly difficult inspection
Illuminance on task, obtained by a combination of general and local (supplementary) lighting:		
G	2000–3000–5000 (200–300–500)	Performance of visual tasks of low contrast and very small size over a prolonged period: fine assembly; very difficult inspection; fine bench and machine work
H	5000–7500–10,000 (500–750–1000)	Performance of very prolonged and exacting visual tasks: the most difficult inspection; extra-fine bench and machine work; extra-fine assembly
I	10,000–15,000–20,000 (1000–1500–2000)	Performance of very special visual tasks of extremely low contrast and small size: for example, surgical procedures

Courtesy of Illuminating Engineering Society of North America.

IESNA Recommended Illuminance Values

Illuminance category	Ranges of illuminance maintained in service, lux (fc)	Type of activity
Illuminance on task:		
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Luminaire Efficiency

- The efficiency of a luminaire is expressed as the ratio of lumens emitted by the luminaire to those generated by lamp or lamps used therein.
  - Lumens per watt
  - Fluorescent and HID lamps are more efficient than incandescent

Designing a lighting plan: process

1. Select luminaires and obtain photomteric data
2. Determine desired footcandles
3. Select room reflectances
4. Assume a light loss factor
5. Calculate room cavity ratio
6. Determine coefficient of utilization
7. Determine required number of luminaires
8. Determine fixture spacing

Example: Dining Room in a SLF

- 50 fc at workplane (IESNA)
- Freedom from glare (disability + discomfort)
- Freedom from veiling reflections
- Freedom from flicker
- Good color rendering

Room Geometry

- Luminaire must be fitted to room geometry
  - Room geometry described by:

CAVITY RATIO

Room Cavity Ratio

- In lighting calculations, a measure of room proportion as determined by dimensions of length, width, and height.

Room Cavity Ratio

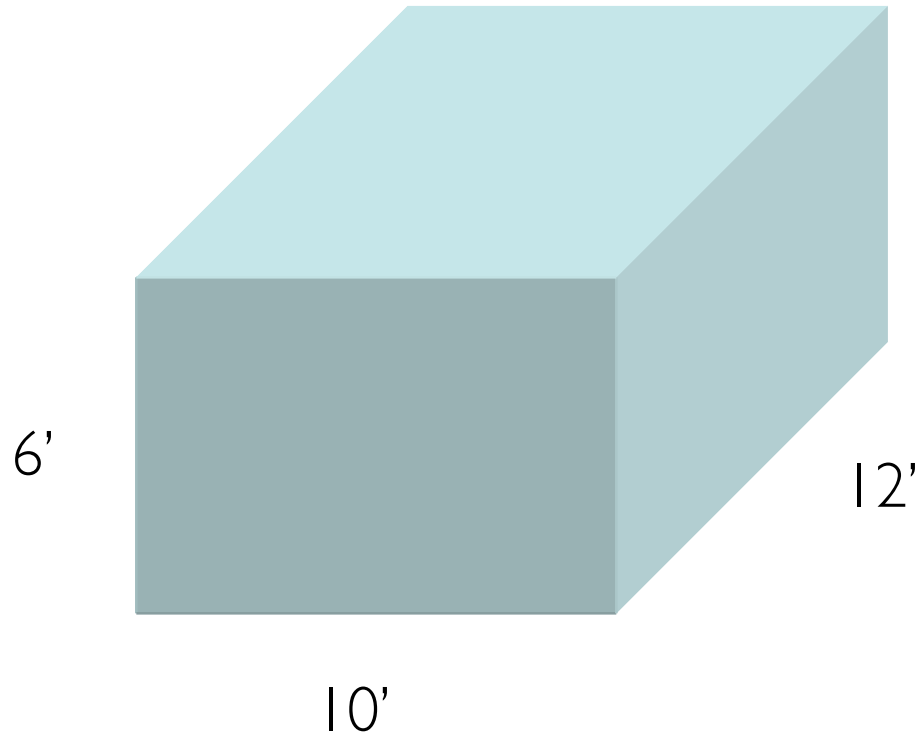
A ratio of room geometry used to quantify how light will interact with room surfaces.

$$RCR = 5h\ (L+W)/(L*W)$$

RCR = 5h (L+W)/(L*W)

5(6') (12+10)/ (12x10) =

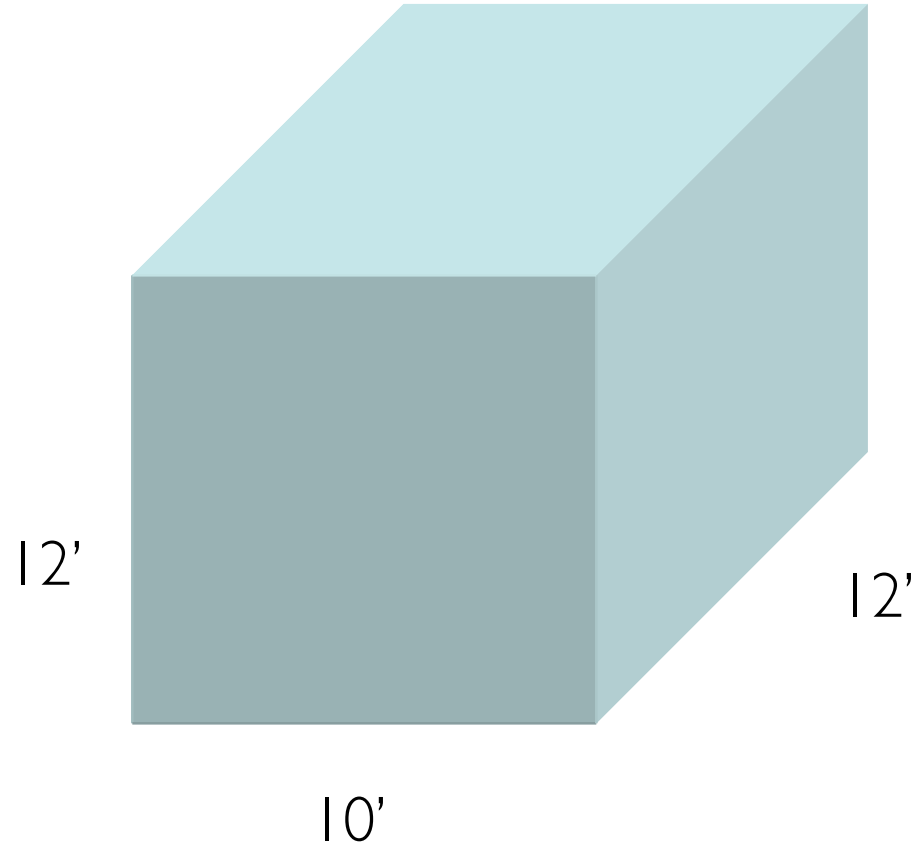
660/ 120 = 5.5



RCR = 5h (L+W)/(L*W)

5(12') (12+10)/ (12x10) =

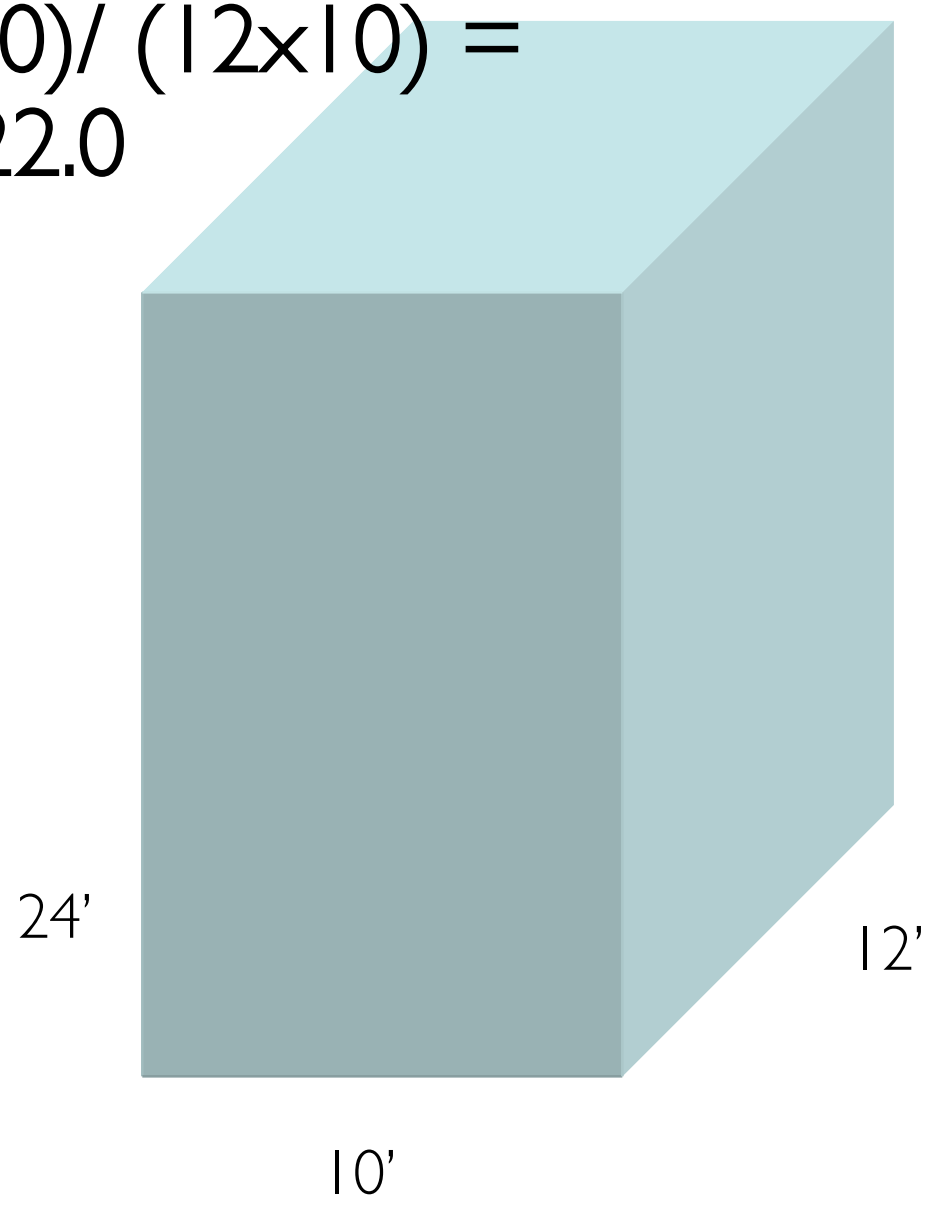
660/ 120 = 11.0



RCR = 5h (L+W)/(L*W)

5(24') (12+10)/ (12x10) =

660/ 120 = 22.0

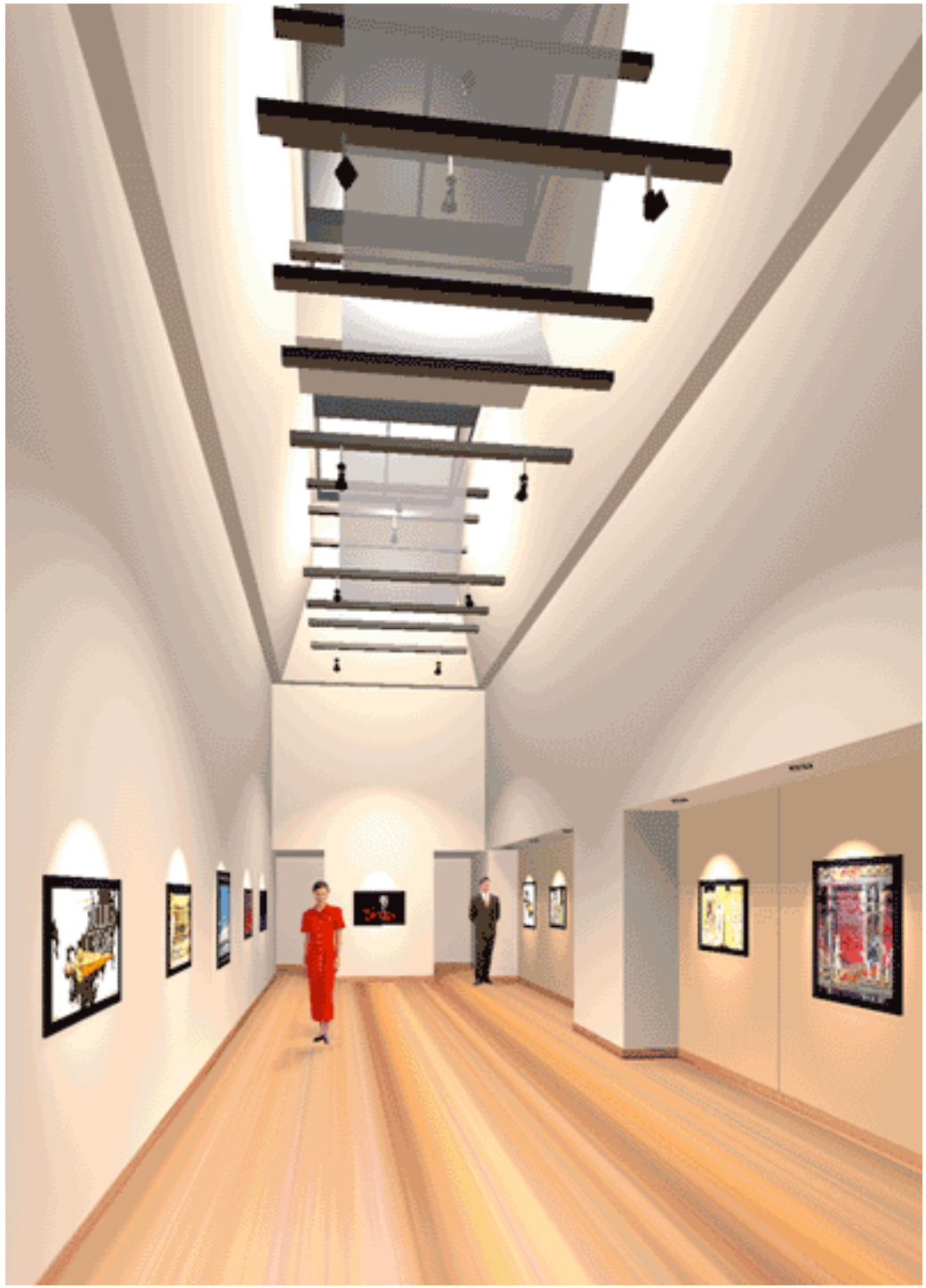


Room Cavity Ratio

- Low, wide rooms have CRC's near 0

Room Cavity Ratio

- Tall, narrow spaces have CRC's greater than 10



Coefficient of Utilization (CU)

- An indication of how efficient the fixture is within a specific room geometry

Coefficient of Utilization (CU)

- How well the fixture gets the lamp lumens onto the work plane.
- Higher the CU, the more light reaches the target

Coefficient of Utilization (CU)

- For a given space, calculate the RCR and then use the fixture manufacturer's CU table to select the appropriate CU.

Room Reflectances

- Determine the CU based on room reflectances
- See paint spec
  - Ideal
    - Ceiling 80%
    - Walls 70%

Spacing Criteria (SC)

- Spacing criterion is the ratio of the distance between luminaire centers and the mounting height above the work plane.
  - Used to determine maximum spacing

Determine Number of Fixtures

- Given
  - Coefficient of Utilization
  - Assume Light Loss Factor (typical LLF for SLF 90% or .9)
  - Using the following formulae determine required number of fixtures

Calculating Average Light Level Throughout a Space

#1

Average Maintained Illumination in Fc (Footcandles) = (Lamps/Fixture x Lumens/Lamp x No. of Fixtures x Coefficient of Utilization x Light Loss Factor) ÷ Area in Square Feet

Dining Room

1. Use combination of light valences, coffered and cove lighting and pendant direct/ indirect
2. Table and chair colors to contrast w/ floor
3. No glass tabes
4. Reduce glare from windows w/ diffusing material (sheers, Mekko shades, etc)
5. Use wall wash luminaires or sconces to light walls
6. Avoid specular surfaces on pendants and sconces

Corridors

1. Avoid scalloping from sconces..even light levels
2. Avoid gloosy floor finishes
3. Clearly define where floor meets wallsconces to meet ADA projection standards
4. Sconces indirect-direct polar graph
5. Ceiling fixtures: luminaire brightness = ceiling brightness


RESIDENT ROOMS
ELEVATORS

Living Rooms

1. Provide lighting levels adequate for the visual task
2. Avoid glare
3. Make general lighting uniform
4. Areas of interest NOT dramatically different from other areas
5. Direct the light to the task
6. Reduce visual clutter (busyness)
7. Provide good color rendition
8. Combine daylight and natural light but protect from glare (lightshelves, overhangs, shears, etc)

Calculating Average Light Level Throughout a Space #2

Average Maintained Illumination in fc (Footcandles) = (Total Lamps x Lumens/Lamp x Coefficient of Utilization x Light Loss Factor) ÷ Area in Square Feet

Calculating Average Light Level Throughout a Space #3

Average Maintained Illumination (Footcandles) = (Total Lamps x Lumens/Lamp x Coefficient of Utilization x Light Loss Factor) ÷ Area in Square Feet

Lumen Method

Required No. of Fixtures = (Desired Average Maintained Light Level x Area in Square Feet) ÷ (Lumens/Lamp x Lamps/Fixture x Coefficient of Utilization x Light Loss Factors)

Lumen Method

- Required Light Output/Fixture (Lumens) = (Maintained Illumination in Footcandles x Area in Square Feet) ÷ (Number of Fixtures x Coefficient of Utilization x Ballast Factor x Light Loss Factor)

Lumen Method

Spacing Between Fixtures = Square Root of (Area in Square Feet ÷ Required No. of Fixtures)

Lumen Method

- Number of Fixtures to be Placed in Each Row (Nrow) = Room Length ÷ Spacing

Lumen Method

- Maximum Allowable Spacing Between Fixtures= Fixture Spacing Criteria x Mounting Height

- Fixture Spacing Criteria: See the manufacturer's literature

- Mounting height: Distance in feet between the bottom of the fixture and the workplane

Room Cavity Ratio

- Room Cavity Ratio (for regular rooms shaped like a square or rectangle) = [5 x Room Cavity Depth x (Room Length + Room Width)] ÷ (Room Length x Room Width)

- Room Cavity Ratio (for irregular-shaped rooms) = (2.5 x Room Cavity Depth x Perimeter) ÷ Area in Square Feet

Summary of Goals

1. Provide lighting levels adequate for the visual task
2. Avoid glare
3. Make general lighting uniform
4. Areas of interest NOT dramatically different from other areas
5. Direct the light to the task
6. Reduce visual clutter (busyness)
7. Provide good color rendition
8. Provide areas for adaptation
9. Determine need for higher levels of lighting to meet photobiological need